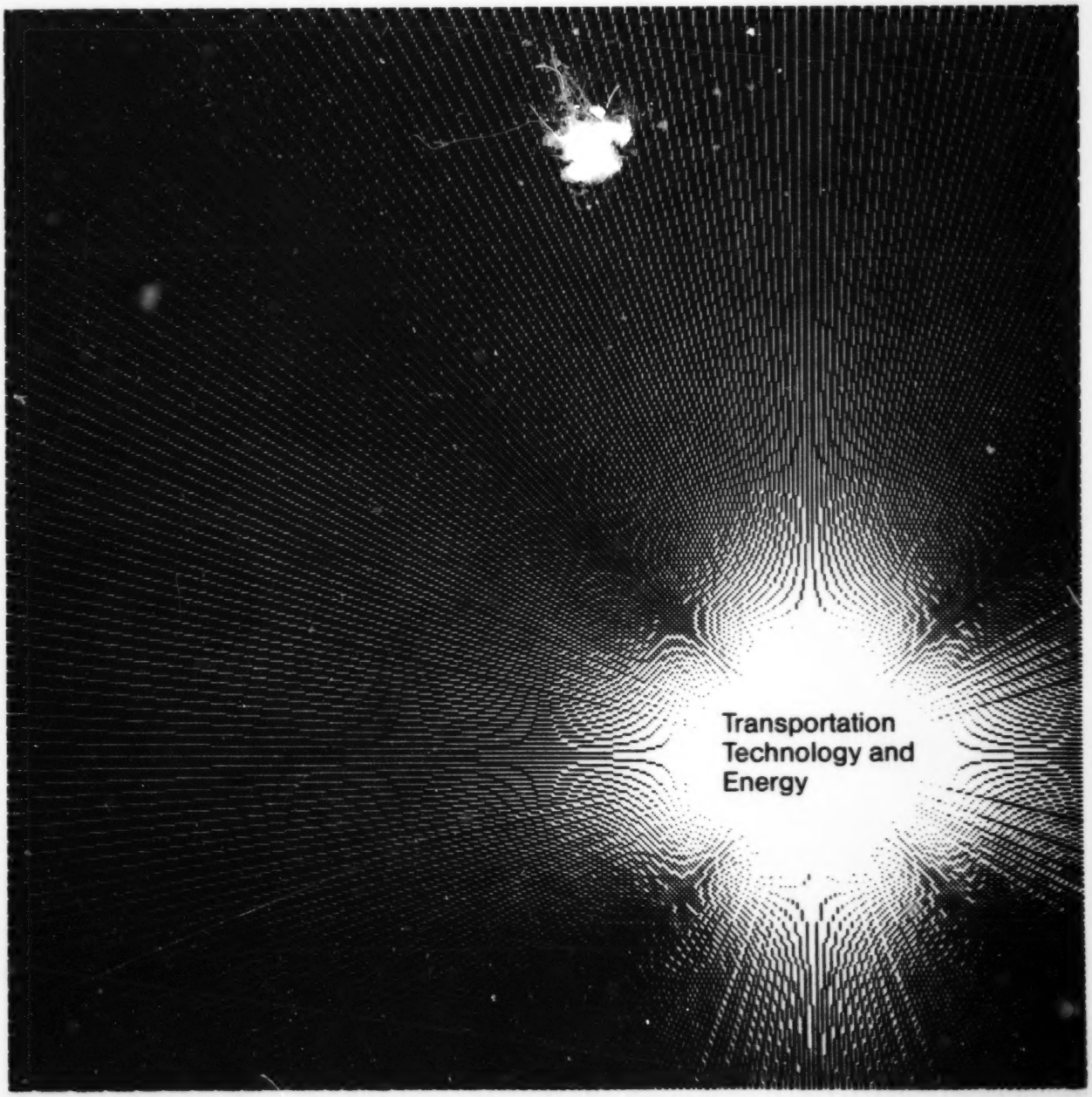
Ontario

Ministry of
Transportation and
Communications

Transportation
Technology and
Energy Branch

Closed-Circuit Television for Vehicles

LAB-84-02



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Technical Report Documentation Page

MTC Report Number: LAB-84-02	ISBN Number:	Other Document Number:	Date: Aug/84

Title: Closed-Circuit Television for Vehicles

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Published by:
The Transportation Technology and Energy Branch, MTC

Client Group:
Transportation Regulation Development Branch, MTC

Participating Agencies:
GO-Transit

Abstract:

This report documents tests of a closed-circuit television (CCTV) system specifically designed to provide commercial vehicle drivers with a wide rearward view, a feature vital to safer operation. Testing was performed during the week of July 23, 1984.

Testing was separated into two parts. Part 1 was to check out the operating characteristics of the CCTV system; Part 2 was aimed at obtaining feedback from very experienced drivers by operating both a GO-Transit bus and a MTC snowplow truck fitted with CCTV under simulated urban street conditions.

This report discusses the results obtained from both parts of the test. Based on the findings from the test, it also makes some recommendations.

Key Words: closed-circuit television, rear-view systems

Comments:

Distribution: On request

Copyright Status: Crown Copyright

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Closed-Circuit Television for Vehicles

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Published by:
Transportation Technology and Energy Branch
Ontario Ministry of Transportation and Communications
Hon. James W. Snow, Minister
H.F. Gilbert, Deputy Minister

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The Editor, Technical Publications
Ministry of Transportation and Communications
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8

August, 1984

NOTICE

This report does not constitute an endorsement by the Ontario Ministry of Transportation and Communications of any particular brand of CCTV. The report is merely a record of an abbreviated study on a typical closed-circuit television system designed for safer operation of vehicles on and off the road.

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ACKNOWLEDGEMENTS

The authors thank Mr D. Mantz, President of Safe-T-Vision Division of Cintec Ltd. for lending two sets of the "Car Vision" CCTV system for the evaluation study. Thanks also go to the management of the Bus Operations Branch, GO-Transit for providing the bus and personnel.

Many thanks to Mr R. Gaunt, Equipment Engineering Office, MTC, for the design and procurement of the mounting brackets for camera and monitor. The authors are also grateful to Messrs I.V.J. McIntosh of GO-Transit Bus Operations Branch, K. Wren of the District 42 Equipment Garage, and G. Walmsley of the District No. 6 Maintenance Section for sharing their valuable experience in support of the driving test assessment.

EXECUTIVE SUMMARY

This report documents tests of a closed-circuit television (CCTV) system specifically designed to provide commercial vehicle drivers with a wide rearward view, a feature vital to safer operation. Testing was performed during the week of July 23, 1984.

Testing was separated into two parts. Part 1 was to check out the operating characteristics of the CCTV system; Part 2 was aimed at obtaining feedback from very experienced drivers by operating both a GO-Transit bus and a MTC snowplow truck fitted with CCTV under simulated urban street conditions.

This report discusses the results obtained from both parts of the test. Based on the findings from the test, it also makes some recommendations. The following is a synopsis of the results and recommendations:

- The CCTV system tested meets the technical specifications as stated by the manufacturer.

- The CCTV system tested cannot easily be converted into a regular broadcast television receiver or video monitor, thus the chance of misuse will be small.

- When mounted at appropriate locations on vehicles, a CCTV system can provide the driver with an increased view to the rear which enables him to manoeuvre the vehicle more safely.

- Much more detailed and longer-term tests would be needed to evaluate the overall impact on driving performance of continuous in-vehicle use of a CCTV system.

- The problem of keeping the camera lens constantly clean under different road and weather conditions was not addressed. Such operating problems can only be solved by potential users themselves.

1/ INTRODUCTION

The Highway Traffic Act, Section 60(2), states that it is illegal to operate a television set visible to the driver in a vehicle. A recent court decision in London, Ontario, interpreted the closed-circuit television monitor as one type of televison set. The Ministry is currently examining the need to amend the Highway Traffic Act to permit the use of television devices as an aid to operating a vehicle. The Transportation Technology and Energy Branch was requested by the Transportation Regulation Development Branch to conduct a brief evaluation test on the use of closed-circuit television as a visual aid for commercial vehicle drivers.

Two identical samples of the Mitsubishi "Car Vision" TV System, type CV-611, were used for the purpose of assessing the operating characteristics of a typical system.

The assessment comprised two parts:

- Part 1 to verify the camera specifications and to provide information on the operation of the CCTV system;

- Part 2 to examine the practicability of the concept by equipping one GO-Transit Bus and one MTC snowplow truck with a "Car Vision" CCTV system and then operating the two vehicles at the former Driver's Licence Test Centre at Downsview.

2/ OBJECTIVES

The following objectives were set for the test program.

1/ Assess the concept of using CCTV systems as a driver's visual aid.

2/ Verify the characteristics of the CCTV systems used and to find out whether the technology is appropriate for application as a visual aid for commercial vehicle drivers.

3/ THE CLOSED-CIRCUIT TELEVISION SYSTEM

The sample CCTV system used for the test program was the Mitsubishi "Car Vision" TV System, type CV-611, made for Cintec Ltd. Figure 1 shows the three basic elements of the system -- the camera, the monitor, and the connecting cable.

3.1/ Specifications

Power Supply	12 V dc
Power Consumption	14 W
Environmental Temperature	-15°C to +55°C
Vibrations	0 to 33 Hz
Shock	4.4 G
Horizontal Effective Field of Vision	100°
Resolution, Horizontal	250 lines
Vertical	250 lines
Camera Lens	f = 6.5 mm; F = 1.8
Camera Pick-up Tube	Vidicon
Camera Weight	4 kg
Monitor Screen	15 cm (6") diagonal
Monitor	Cathode ray tube
Monitor weight	4 kg

4/ TESTING

Part 1 of the testing program was to check out and verify the operating characteristics of the CCTV system as stated in its specifications. These results are reported in Section 4.1, below.

Part 2 assessed the practicability and the usefulness of the CCTV system in improving a driver's viewing area, especially by reducing blindspot areas. Results of this part of the study are reported in Section 4.2.

4.1/ Operating Characteristics of the Sample CCTV System

The operating characteristics tests were carried out mostly in a laboratory environment.

4.1.1/ Power Supply

The nominal required power supply is 12 V dc with negative ground. Current loadings under different voltage levels are shown in Table 1.

4.1.2/ Effective Field of View

Figure 2 shows the test set-up. The camera was mounted with the lens facing down at a height of 254 cm (100 inches) above the floor. (This distance is designated ZO in the figure.)

The distances designated OL, OR, OT, OB OC, and OD in Figure 2 were measured. The results are summarized in Table 2.

4.1.3/ Cold Weather Performance

To simulate winter operation, the camera unit was placed in a cold room set at -20°C and "soaked" for more than six hours. The unit still functioned properly when connected to its monitor.

4.1.4/ Capability to Receive Broadcast TV

Unlike a conventional television camera, in the CCTV system tested the camera and monitor do not have independent functions. They were designed

to function as a composite pair. Certain circuits that perform functions normally considered to be part of a conventional video camera are packaged in the monitor. Conversely, certain circuits performing functions normally considered part of a conventional video monitor are packaged in the camera. It would thus be quite difficult, even for an expert, to convert the monitor into a regular black and white TV receiver or video monitor.

4.2/ Simulated On-Road Test

Two vehicles were selected to simulate the on-road operation condition. A GO-Transit GM bus, No. 1094, was used to test the effectiveness of the CCTV in a backing-up manoeuvre. An MTC snowplow truck, MTC 74-350-051, equipped with snowplows was used to test the effectiveness of the CCTV for a better control of the plow positions. In both cases, the effectiveness of the CCTV system in assisting the operator and improving his visual information was carefully examined.

4.2.1/ Bus Backing-up Manoeuvre

One set of the CCTV system was installed on the No. 1094 GO-Transit short-haul bus. The camera was mounted at the rear outside of the bus in the centre. The monitor was installed at the fare collection box location. The set-up was intended to enable the operator to see areas behind the bus which were normally not visible to him by using side mirrors alone.

4.2.1.1/ Camera mounting

The camera was mounted at the rear outside centre of the bus at a height of 2.59 m (8'6"). The tilting angle of the camera was such as to have the rear bumper coincide with dot 0 in Figure 3. The figure gives a general view of the camera mounting position and the perspective of the camera view shown on the monitor screen. Figure 4 shows a view of the rear of the bus and the area behind it. The pylon cones are positioned to coincide with the dots marked on the monitor screen. Figure 5 shows a reverse view of the area marked in Figure 4 as it appears on the monitor screen.

4.2.1.2/ Driving Test

A number of manoeuvring tests were carried out with the GO-Transit bus and subjective assessment of the CCTV system was obtained from the vehicle operator.

The bus was reversed within intersections having 4-lane/2-lane and 2-lane/2-lane configurations at the former Falstaff Driver Examination Test Centre. The bus was also driven into and reversed out of both the GO-Transit Bus Garage at Downsview and passenger loading bays at the Yorkdale GO-Transit Bus Terminal. These manoeuvres were carried out under three conditions, depending on the manoeuvre:

- side mirrors only were used, or
- the monitor screen only was used, or
- a combination of both was used.

4.2.2/ Snowplow Truck Operation

In snowplow operations, the plow operator must frequently scan forward and rearward to ensure safe operation of the wing-blade. The camera mounting position was selected to enable the operator to see areas between the side of the truck and the wing-blade and to provide a partial view of the area behind the truck.

4.2.2.1/ Camera Mounting

The camera was mounted above the passenger door, 2.92 m above ground, on the highest longitudinal frame member associated with the plowing equipment. Figure 6 shows a plan view of the truck and the reference pylon cones with the X-Y co-ordinates marked in metres. Figure 7 shows the area as seen looking down from the camera position. Figure 8 shows the same area as viewed on the monitor.

4.2.2.2/ Driving Test

The snowplow truck was driven forward around the Falstaff Driver Test Centre with the plow and wing-blade lowered. Manoeuvres were tried using the side-mirrors only at times, and the monitor screen only at other times.

4.2.3/ Comments from Operators

4.2.3.1/ GO-Transit Bus

The bus operator felt it would be possible for someone to use the monitor screen alone (rather than mirrors) to manoeuvre the bus in reverse. However, he did not feel comfortable about the camera lens distortion of distances as perceived on the screen. Another problem was the sudden change of screen brightness which occurred whenever the bus entered an area where lighting conditions changed greatly in contrast. Using the brightness and/or contrast controls could remedy this problem.

During the test drive, the operator manoeuvred perfectly when the side-mirror only was used. The smoothness and accuracy of the operation exceeded that observed when manoeuvring with the monitor screen only.

There was no significant vibration of the monitor screen image while the bus was moving forward or in reverse. However, the temporary mounting of the monitor on the fare box sub-frame was too low.

4.2.3.2/ MTC Snowplow Truck

The operator and "wing-man" (the co-driver responsible for the wing-blade) thought that the information on the monitor screen was superior to the door mirror for detecting vehicles that might be trapped by a movement of the truck to the right.

However, the relative value of the monitor compared to a 10-inch convex mirror mounted above the right fender was unknown as no such mirror was fitted to the test snowplow truck. One advantage of the CCTV system was that the camera gave slightly more information about vehicles following to the rear of the truck.

The snowplow operator noted, as did the GO-Transit bus operator, that the wide-angle distortion of the camera lens made it difficult to gauge the relative position of objects appearing on the monitor screen. However, the system did enable easy detection of objects.

The position of the monitor screen was good and there was no problem from vibration, either of the camera, or of the screen. During the test, there was slight electrical interference on the screen image.

4.3/ Results

4.3.1/ Power Supply Requirement

The CCTV system tested operates at 12 V dc. Its power consumption is 15 W at 12 V dc, and it takes 4.6 W when switched onto STANDBY mode. A minimum of 8 V dc is required to turn the CCTV system ON.

4.3.2/ Effective Field of View

It was confirmed that the horizontal and vertical field angles of the camera were 100° and 80°, respectively.

4.3.3/ Cold-Weather Performance

The camera operated properly after being "cold soaked" for more than six hours at a temperature of -20°C.

4.3.4/ Convertibility to Normal TV Receiver

It was confirmed that the tested CCTV monitor could not easily be converted into a normal TV receiver. Reasons for this include the fact that the CCTV system produces a mirror image which differs from the TV camera used in consumer-type video systems, and the monitor and camera cannot function independently.

4.3.5/ Simulated On-Road Test

Both the GO-Transit bus operator and the MTC snowplow operator agreed that the effective field of view of the camera provided an expanded mirror image of the area under scrutiny. For the bus, it enabled the operator to check an area behind the bus that is impossible to monitor by the side-mirrors alone.

In the case of the snowplow test, the information on the monitor screen was better than the door mirror for detecting vehicles that might be trapped by a movement of the truck to the right. However, its value over a 10-inch convex mirror mounted above the right fender was less certain as comments by the operator and the "wing-man" indicated that the camera would give only slightly more information about following vehicles to the rear of the truck.

It is worth noting that the test was carried out in dry warm weather, which is the opposite extreme of the environment when snowplows are usually operating.

5/ CONCLUSIONS

The CCTV system tested does expand the driver's viewing area as compared to conventional side rear-view mirrors.

The circuit designs of the CCTV system tested are incompatible with conventional video television systems and, even for an electronic expert, it would be very difficult and economically impractical to convert the CCTV monitor to receive regular broadcast television or to display consumer video signals. The chance of vehicle operators misusing the particular CCTV system tested will be minimal.

The test on the CCTV system was very brief. It did not adequately cover human factors considerations. To assess the effects on driving performance, much longer and more elaborate testing would be needed.

The picture clarity of the tested CCTV system was not sharp due to its low resolution, though it was adequate to determine the presence of obstacles. It is expected that should a market for CCTV systems become established, competition will promote the development of products with higher resolution.

Keeping the camera lens clean under all types of road and weather conditions is still a problem of unknown dimension. It has to be resolved according to each application and to individual vehicle geometry.

CCTV systems should be used as a <u>supplement</u> to conventional rear-view mirror systems. They should not be considered as a <u>replacement</u> for mirror systems.

CCTV systems may find similar application in vehicles operating off-road. Such applications may be penalized by the present law if the vehicle is required to use the highway occasionally.

6/ RECOMMENDATIONS

1/ It is recommended that closed-circuit television systems especially designed for the sole purpose of improving and expanding the driver's view and to enhance the safety and ease of vehicle operation should be legally permitted to be installed within the driver's cab.

2/ The ability of the driver/operator to use the monitor screen and the manner and extent of his usage should be systematically examined to determine the effect on driving performance of having another source of information to process. Additionally, the driver's ability to effectively utilize the information provided by the image needs to be determined.

3/ New dashboard instrument displays and electronic map systems designed to assist the driver in route finding are being developed[1]. It is likely that other such devices will be developed in future using micro-electronic technology to reduce the driver's workload and improve safety. These systems may use cathode ray tubes, liquid crystal displays, or other forms of information display. They should be considered in any amendment to the Highway Traffic Act or its regulations.

4/ Longer-term on-road tests of the closed-circuit television systems will be needed to solve the basic problem of how to keep the camera lens clean under all kinds of road and weather conditions.

5/ Organizations such as GO-Transit, Toronto Transit Commission and trucking firms should be encouraged to investigate the usefulness of such CCTV systems in improving operating safety in their daily and potential applications.

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[1] "Super-Smart Cars," Popular Science, August 1984)

Table 1/ Power Supply Requirement

Voltage (Volts dc)	Operating Mode: ON Current (Amps dc)	ON Power (Watts)	STANDBY Current (Amps dc)	STANDBY Power (Watts)	Remarks
6.0	3.0				Picture blurred.
7.0*	2.7	18.9	0.66	4.6	
8.0	2.2	17.6	0.58	4.64	
9.0	1.8	16.2	0.51	4.59	
10.0	1.6	16.0	0.45	4.5	
11.0	1.4	15.4	0.42	4.62	
12.0	1.25	15.0	0.38	4.56	
13.0	1.17	15.2	0.35	4.55	
14.0	1.08	15.1	0.33	4.62	
14.5	1.05	15.2	0.32	4.64	
15.0	1.02	15.3	0.31	4.65	
16.0	0.96	15.4	0.29	4.64	

* A minimum of 7.95 V dc is needed to switch operating mode from STANDBY to ON.

Table 2/ Effective Field of View

Distance	Angles	Field Angles
ZO = 254 cm		
OL = 284 cm	< LZO = 52.9°	Horizontal = 101°
OR = 335 cm	< RZO = 48.2°	
OT = 244 cm	< TZO = 43.8°	Vertical = 80°
OB = 185 cm	< BZO = 36.1°	
OC = 409 cm	< CZO = 58°	Diagonal = 111°
OD = 340 cm	< DZO = 53°	

Note: -- The asymmetry of the measurements was a result of the camera position. It was not aimed truly perpendicular to the floor surface.

Measurement of the effective field of view, shows that the monitor gives a mirror image which differs from conventional video cameras.

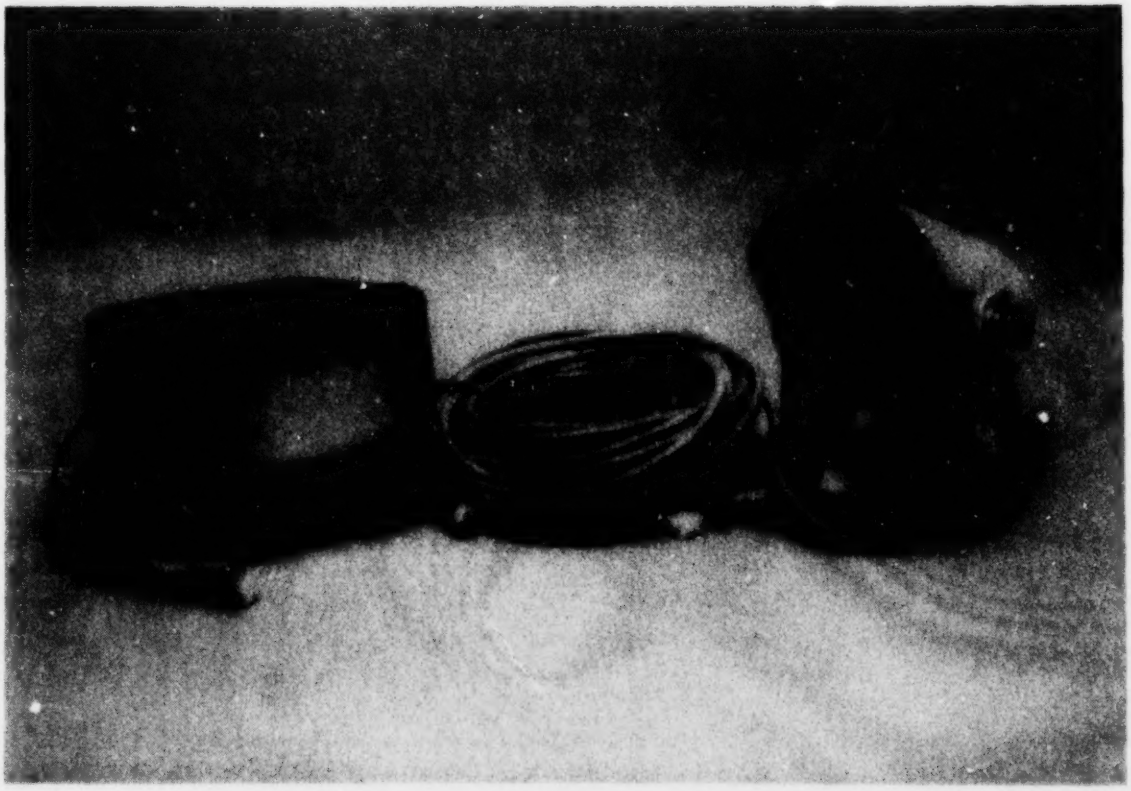


Figure 1/ Car Vision CCTV System

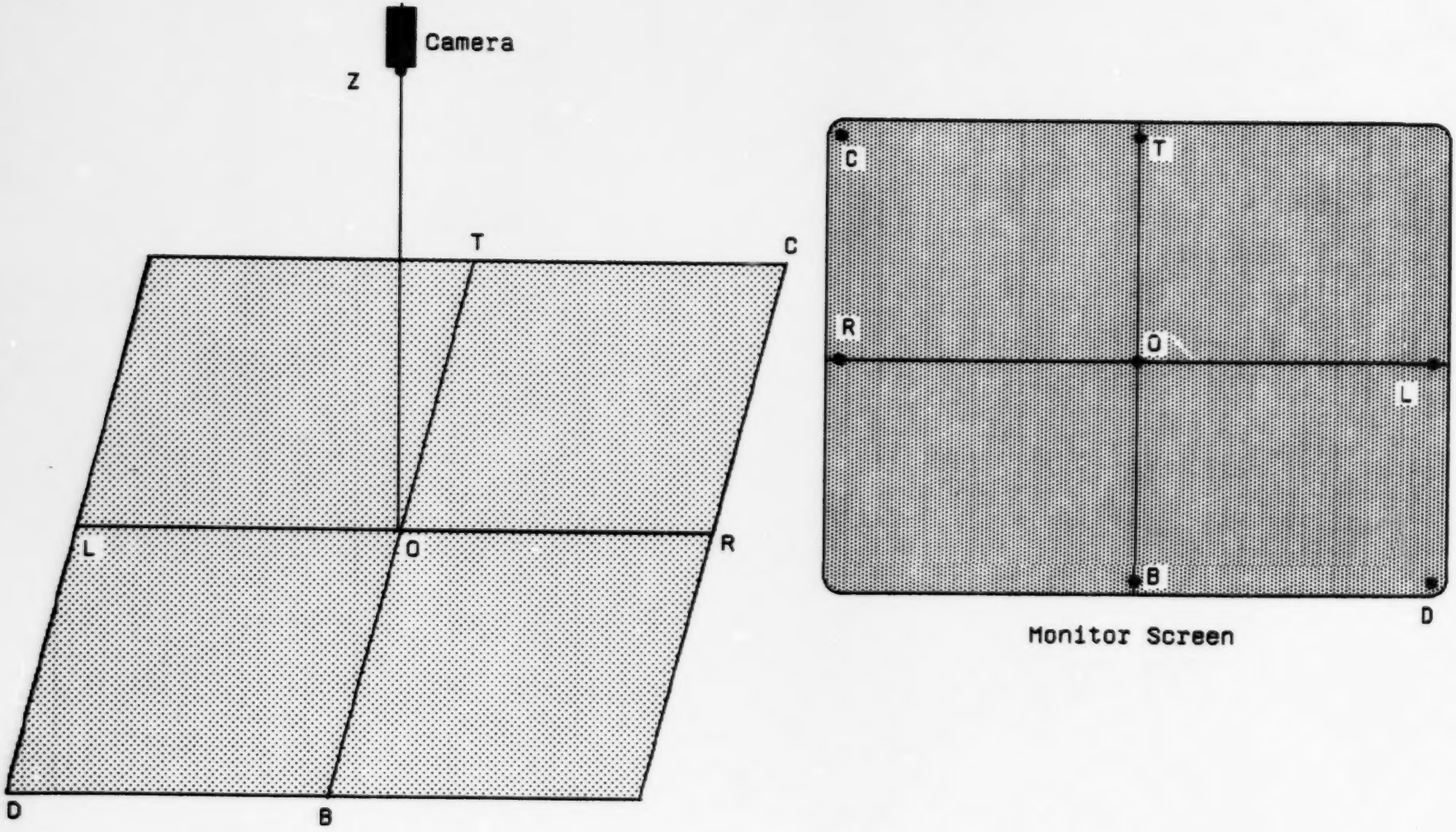
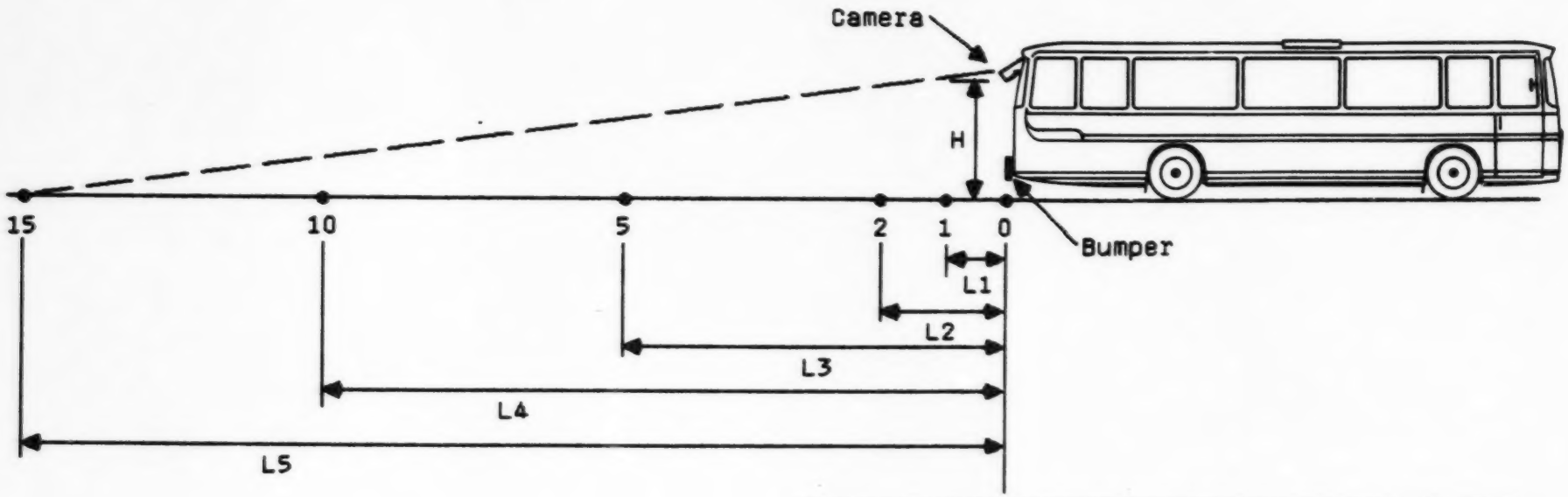
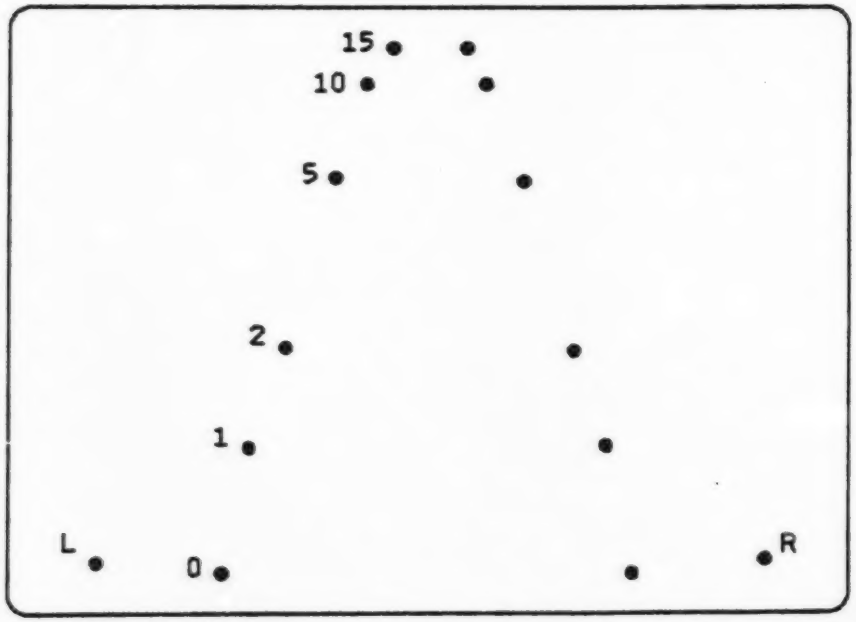


Figure 2/ Measurement of Effective Field of View





Position		Measurement
Camera Height H		2.59 m (8'-6")
Dot 0		Under the Bumper
Dot 1	L1	0.914 m (3'-0")
Dot 2	L2	1.929 m (6'-4")
Dot 5	L3	4.420 m (14'-6")
Dot 10	L4	7.977 m (26'-2")
Dot 15	L5	12.283 m (40'-4")
Dot L - Dot R		3.962 m (13'-0")

Figure 3/ Camera Mounting - Bus

Figure 4/ Areas at Back of the Bus

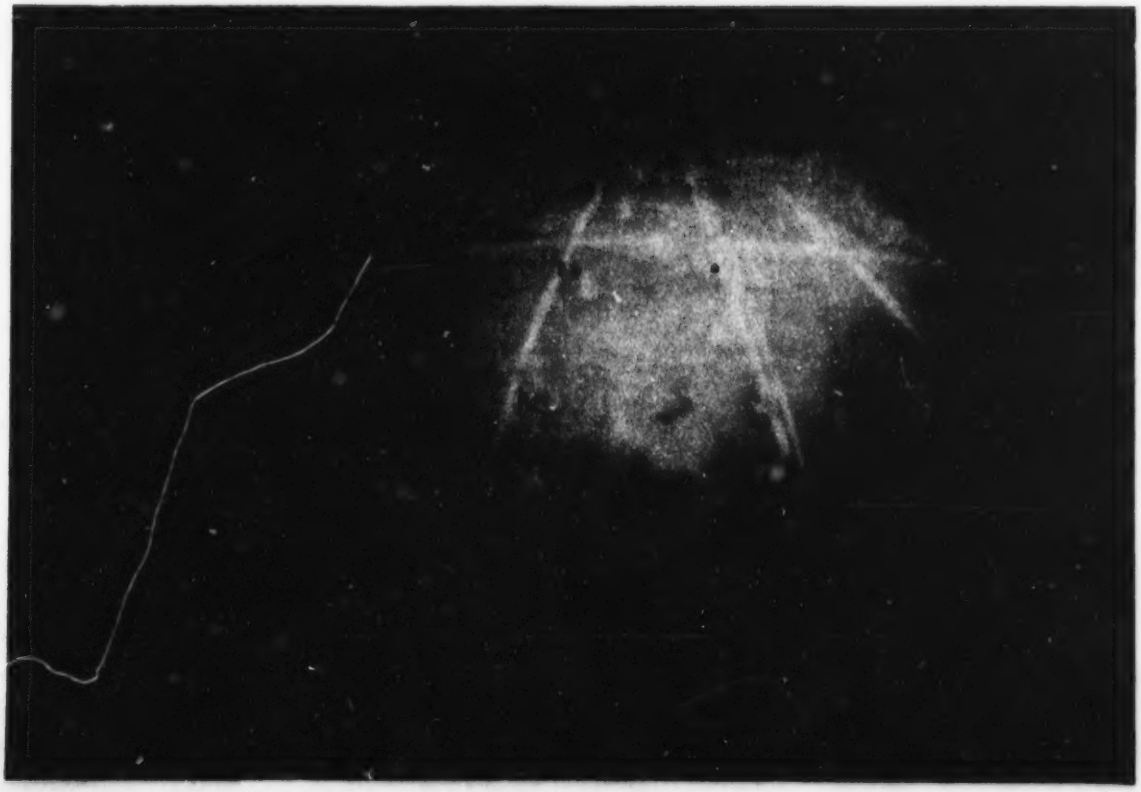


Figure 5/ Areas at Back of the Bus on Monitor

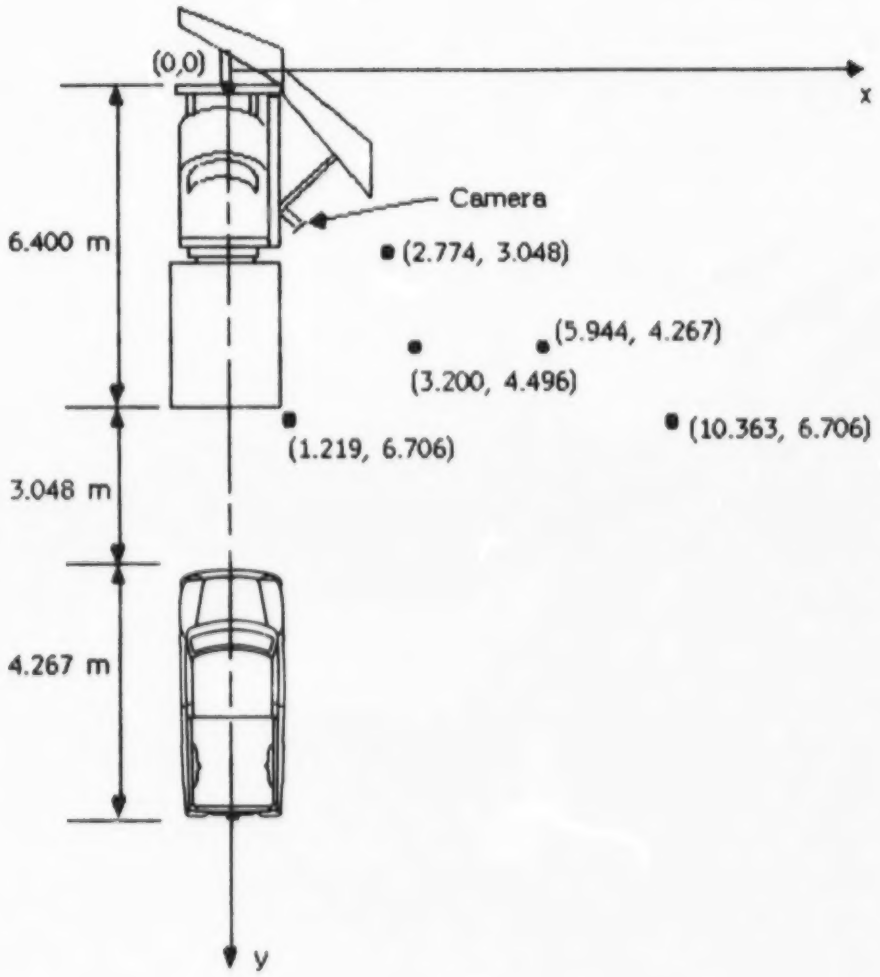


Figure 6/ Marking Pylon Positions - Snowplow Truck

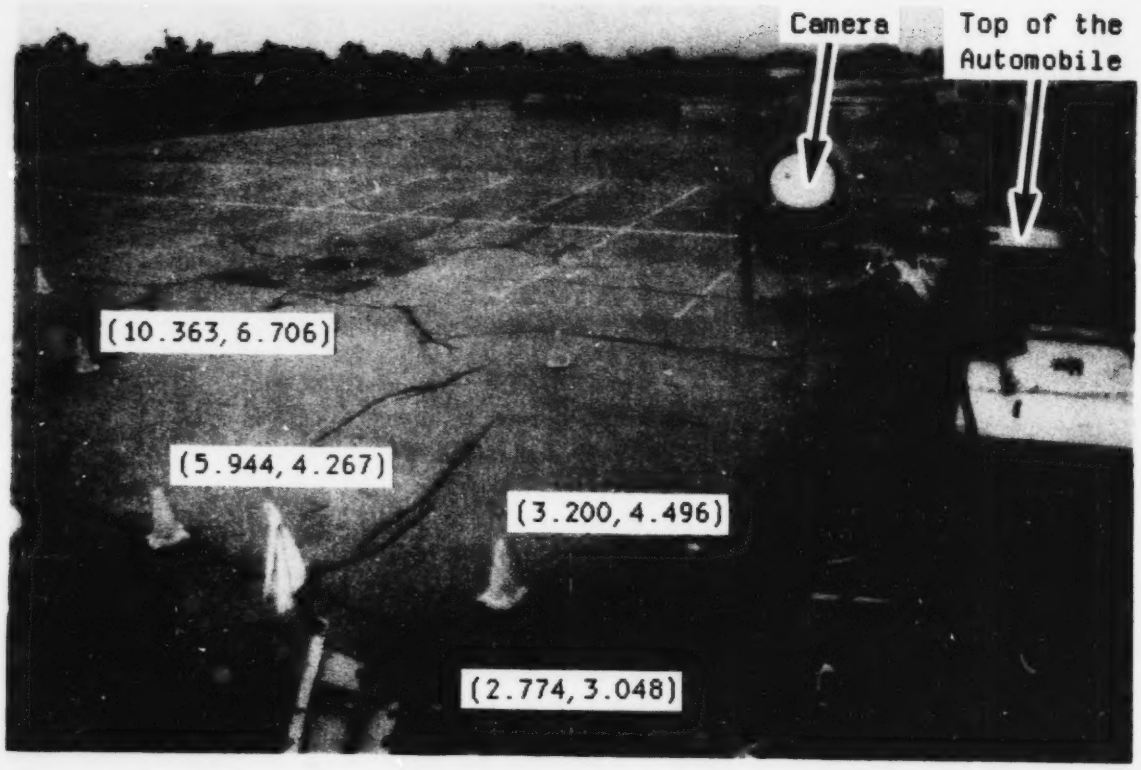


Figure 7/ Areas Covered by the Camera - Snowplow Truck

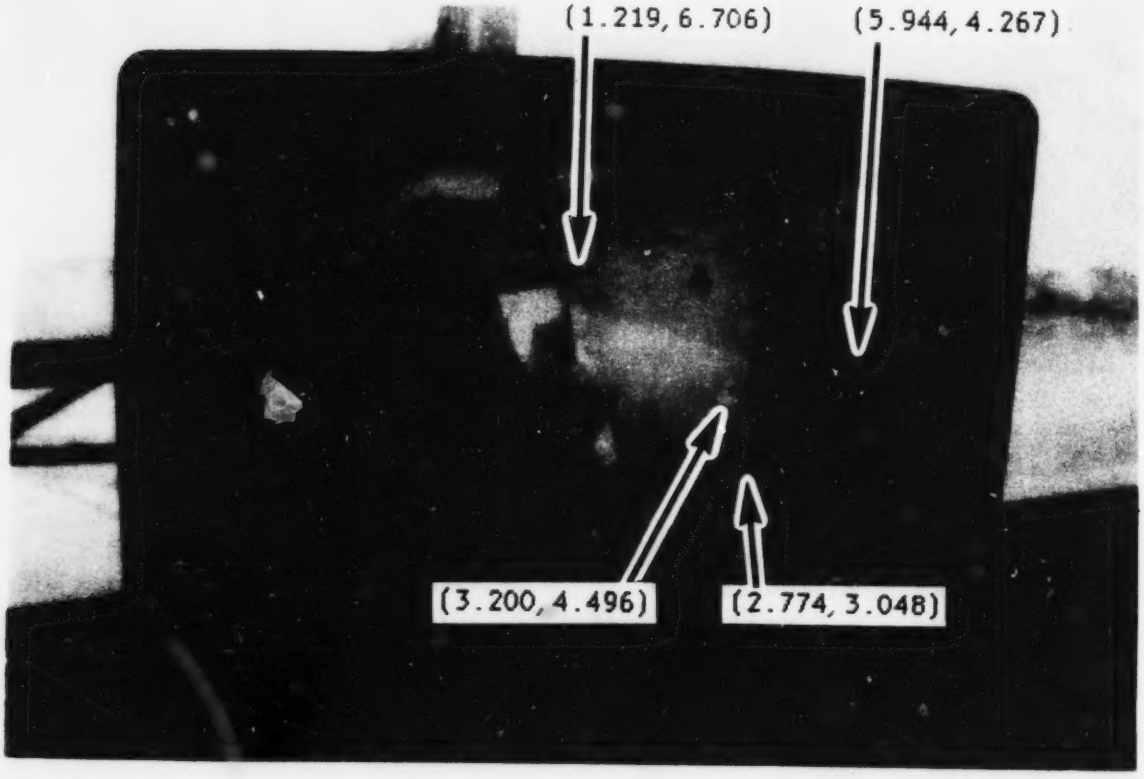


Figure 8/ Screen View of Areas Covered by the Camera - Snowplow Truck

POOR

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